

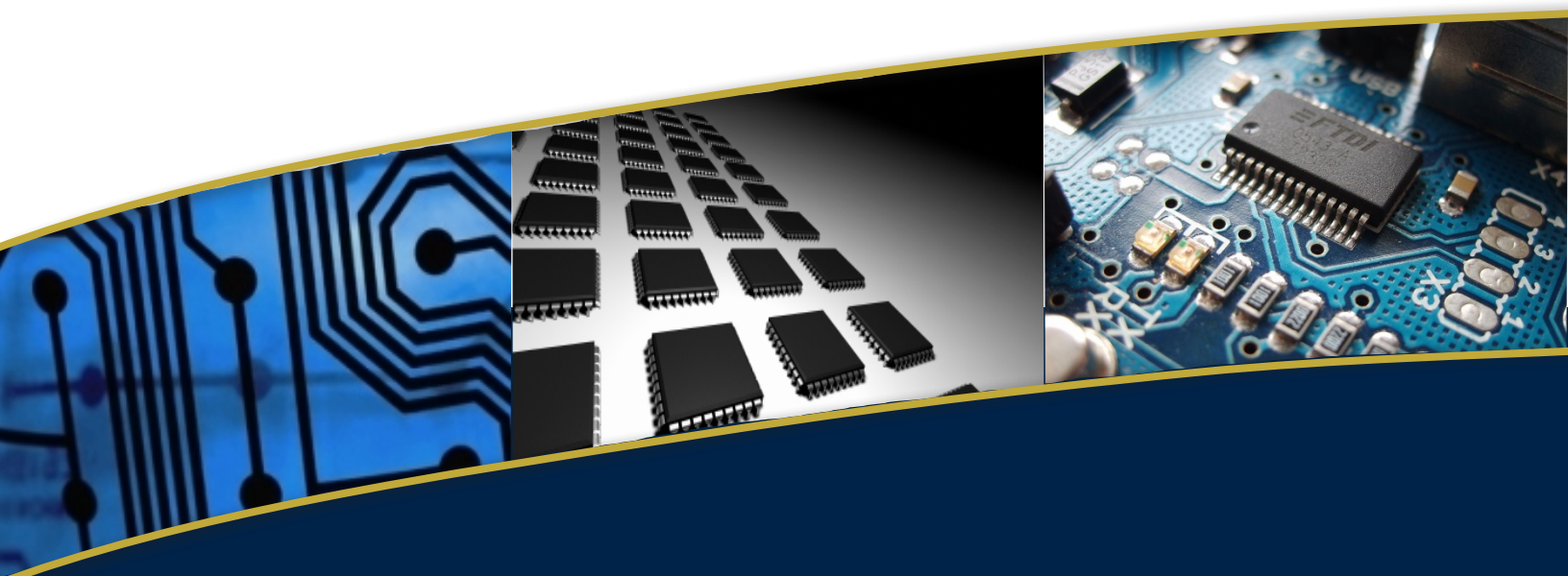


INTERNATIONAL
TRADE
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2015 Top Markets Report **Semiconductors and Semiconductor Manufacturing Equipment**

A Market Assessment Tool for U.S. Exporters

July 2015



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Executive Summary and Key Findings

The U.S. semiconductor industry is the leading provider of semiconductors to the world, with a majority of global market share. U.S. companies also lead in the semiconductor manufacturing equipment (SME) sector, accounting for 44 percent share of the world market.¹

Semiconductors

Semiconductors were America's number three manufactured export over the last five years and 2014 sales were \$172.9 billion and had 51 percent of the \$335.8 billion global market.² Global semiconductor sales were up 9.9 percent in 2014 and are forecast to keep growing through 2016, albeit at a slower pace than in 2014. Nine out of the top 20 semiconductor companies are American.

Electronics production is what drives semiconductor demand and a great deal of this production has moved to Asia over the last several years. Current growth in electronics production is the main driver of the global semiconductor industry. Growing demand for smartphones, tablets, digital televisions, wire-less infrastructure, network hardware, computers, automobile electronics, industrial electronics, and electro-medical devices are stimulating global demand of semiconductors. The Internet of Things (IoT) – aka, internet connected devices – is in its infancy, but will contribute significantly to semiconductor demand over the long term, as will the development of Smart Grids and Smart Cities. The automotive and industrial markets for semiconductors also offer significant growth potential.

Top markets for U.S. semiconductor sales include China, Japan, Germany, and South Korea. All of these countries exhibit vast amounts of electronics production. China has been called the “factory of

the world” when it comes to electronics, and its population has a seemingly insatiable appetite for smartphones and consumer electronics; Japan has plenty of consumer electronics production as well as a very large automobile manufacturing sector; Germany has the largest automobile manufacturing industry in Europe as well as the largest industrial base; and Korea is a powerhouse in consumer electronics manufacturing and has a vibrant automobile manufacturing industry.

Semiconductor Manufacturing Equipment

Five markets account for over 85 percent of worldwide sales of semiconductor manufacturing equipment creating a very concentrated market: Taiwan, South Korea, China, Japan and the United States. Europe and the Middle East represented another six percent, and other markets (primarily in Southeast Asia) account for six percent of the world market.³

Challenges Facing U.S. Semiconductor and Semiconductor Manufacturing Equipment Exports

Overall, the markets for semiconductors and semiconductor manufacturing equipment are open, as most of the markets are participants in the WTO Information Technology Agreement (WTO ITA). As a result, most semiconductors and semiconductor manufacturing equipment enter most markets duty-free. Some types of new-technology semiconductors – Multi-Component semiconductors (MCOs) – and some types of semiconductor

Figure 1: Projected Top Markets for Semiconductor Exports (2015-2016)

1. China
2. Japan
3. Germany
4. South Korea
5. Singapore
6. Mexico
7. Taiwan
8. Malaysia
9. Brazil
10. Thailand

Figure 2: Projected Top Markets for Semiconductor Manufacturing Equipment Exports (2015-2016)

1. Taiwan
2. South Korea
3. China
4. Japan
5. Singapore
6. Germany
7. Netherlands
8. Ireland
9. Israel
10. Malaysia

manufacturing equipment are not clearly covered in the Agreement. These goods are the subject of the on-going negotiations to expand the scope of products covered under the WTO ITA.

Semiconductors

U.S. semiconductor companies face the challenges of weak IPR enforcement, counterfeit semiconductors, poor patent quality, and lax patent enforcement in developing countries, and the rise of China's semiconductor industry as a competitive threat – through the Government of China's inception of a National Integrated Circuits Industry Development Plan that may pump up to \$150 billion to develop its domestic industry over the next ten years.

The stiffest competitors for U.S. semiconductor companies comes from Korea and Taiwan in the short term and China in the long term. Japan and the EU are currently trying to increase the competitiveness of their industries.

Semiconductor Manufacturing Equipment

Japan is a leading manufacturer and the United States' major competitor in the global market for semiconductor manufacturing equipment. There are also some IPR problems for semiconductor manufacturing equipment in all regions, but notably in Korea (see Korea country case study).⁴

Country Case Studies

The Department of Commerce's International Trade Administration identified five markets as top markets for both semiconductor and semiconductor manufacturing equipment. These countries are subjects of in-depth case studies: China, Germany, Japan, South Korea and Taiwan. This list includes the four largest markets for both the semiconductor and

semiconductor manufacturing equipment (SME) sectors. Taiwan is in the top four for SME (ranked first), Germany is in the top four for semiconductors (ranked third), but neither rank in the top four for the other subsector. Germany is the largest European market for both semiconductors and semiconductor manufacturing equipment. These case studies describe each market's semiconductor and SME market and recommend specific actions tailored to the unique conditions of each market. The full list of subsector rankings is located in Appendix 2.

Methodology

The purpose of this methodology is to calculate the ranking of export markets for U.S. semiconductors and semiconductor manufacturing equipment for 2014 and to project exports into the future. This is relatively straightforward for semiconductor manufacturing equipment. However, it was difficult in the case of semiconductors.

Due to the large volume of U.S. semiconductor exports solely for final assembly and packaging,⁵ and re-exports of semiconductors for testing and transshipment, U.S. export data for semiconductors is not usable to determine best markets. In addition, market share and future data for China was incompatible with other semiconductor industry data, therefore market share and future data could not be used for semiconductors. Therefore, we used proxy data including size of semiconductor markets, electronics equipment production and world import data to determine best export markets for semiconductors. To project the size of each country's potential export market for U.S. companies, we used the formulas described in Figures 3 and 4.

Figure 3: Methodology for Ranking Markets (Semiconductors)



Figure 4: Methodology for Ranking Markets (Semiconductor Manufacturing Equipment)



Sector Snapshots

This section contains sector snapshots that summarize export opportunities in both semiconductors and semiconductor manufacturing equipment. The overviews outline ITA's analysis of the export potential across each technology's supply chain. The snapshots provide subsector rankings and describe the different markets that U.S. exporters sell into. Each snapshot offers commentary on the relative competitive position of U.S. suppliers.

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Sector Case Study: Semiconductors

The U.S. semiconductor industry is firing on all cylinders and is growing due to the proliferation of electronics products globally. The vast majority of electronics production is concentrated in the Asia-Pacific region presenting export opportunities for U.S. companies. As a result, exports to the Asia-Pacific region continue to grow faster than exports to the European Union and Latin America. U.S. companies are leaders in this industry, but face stiff competition from South Korea and Taiwan.

The U.S. semiconductor industry is the leading supplier of semiconductors to the world, with a majority of global market share. Semiconductors are America's number three manufactured export over the last five years and 2014 sales were \$172.9 billion and had 51 percent of the \$335.8 billion global market.⁶ U.S. sales are estimated to grow seven percent in 2015 and five percent in 2016.

Semiconductors are materials that partially conduct electricity. There are three types of semiconductors: discrete semiconductors – having one diode and transistor; integrated circuits (ICs) having up to several billion transistors on one chip; and system-level products, typically multiple ICs on a solid or flexible printed circuit board (PCB) encased in a single package. Semiconductors are the “brains” inside electronics and make the global trillion dollar electronics industry possible.⁷

There are three main types of semiconductor companies: **Fabs**, which design, manufacture, and sell their own semiconductors, such as Intel or Samsung – fabs are also known as Independent Device Manufacturers (IDMs); **Dedicated Foundries**, which are essentially “factories for hire” with the sole purpose of manufacturing semiconductors per customers' specifications; and **Fabless**, otherwise known as designers of semiconductors who contract out the manufacture of their proprietary designs to either Dedicated Foundries or fabs with spare manufacturing capacity.

Semiconductor applications or end markets can be divided into six categories: **1) Communications** is the largest end-market – growth in this area is driven currently by demand for smartphones and wireless networks and in the not too distant future by the Internet of Things (IoT) -- connected devices in the home or workplace; **2) Computers** – growth in this

area is being driven by demand for tablets; **3) Consumer Electronics** – leading growth in this category are digital TVs including game consoles, audio for home theater systems, blue tooth enabled speakers, the sudden proliferation of fitness wearables that track just about every part of your day, and in the not too distant future by the Internet of Things (IoT) ; **4) Automotive Electronics** -- advanced electronics now control just about every aspect of the automobile, and the installation of “infotainment” systems is growing especially fast ; **5) Industrial/Medical** -- smart grids, smart cities, factory automation and robotics, and health IT are major forces at work in the category; and **6) Government and Military contracts.**

U.S. Semiconductor Export Base

Semiconductors drive innovation and are key components of computers, telecommunications equipment, consumer electronics, automobiles, aviation equipment, medical equipment, industrial and commercial machinery, and critical infrastructure.

Top Semiconductor Export Markets to 2016

1. China
2. Japan
3. Germany
4. South Korea
5. Singapore
6. Mexico
7. Taiwan
8. Malaysia
9. Brazil
10. Thailand

The semiconductor industry directly employs about 250,000 workers in the United States, and for every direct job, there are an estimated 4.89 jobs supported in other parts of the U.S. economy.⁸ That equals approximately 1.2 million additional jobs; even more impressive is that a job in the semiconductor industry pays on average 2.5 times more than the average salary for all U.S. workers. Samsung has invested \$13 billion in a state-of-the-art semiconductor manufacturing fab in Austin, Texas – the single largest foreign direct investment in the United States.

The semiconductor industry is consistently among the top U.S. exporting sectors, and a worldwide leader in R&D, design, and manufacturing. The industry is a driver of innovation, productivity, and high wage jobs. Semiconductor production in the U.S. is concentrated in California, Oregon, Texas, Arizona, and New York.

The U.S. share of world semiconductor exports does not measure the true U.S. share of the global market, due to the high volume of re-exports for testing and packaging/final assembly⁹. The industry's preferred measure of competitiveness is sales: sales by U.S. firms within the United States, direct U.S. exports, sales by U.S.-owned overseas subsidiaries, and foreign sales of U.S. chips fabricated under contract overseas, rather than U.S. exports and imports alone, which reflect only the movement of goods.

The U.S. is the world's leader in semiconductor sales and nine out of the top 20 semiconductor companies are American. In 2014, U.S. semiconductor firms generated \$172.9 billion in sales and had 51 percent of the \$335.8 billion global market.¹⁰ The stiffest competition to U.S. industry currently comes from South Korea and Taiwan. The industries in Japan and the EU were once formidable competitors, but not anymore, at least in the short-term perspective.

Overview of Global Export Market Opportunities

Current growth in electronics production is the main driver of the global semiconductor industry. Growing demand for smartphones, tablets, digital televisions, wire-less infrastructure, network hardware, computers, industrial automation and robotics, automobile electronics, and electro-medical devices are stimulating global demand of semiconductors.

The Internet of Things (IoT) – aka, internet connected devices -- is in its infancy, but will contribute significantly to semiconductor demand over the long term, as will the development of Smart Grids and Smart Cities.

The Asia-Pacific region is the fastest growing market as consumer demand, packaging of semiconductors, and electronics systems production has shifted to this region. China is by far the largest end market for semiconductors in the world, accounting for an estimated 50 percent -- \$153 billion -- of the \$306 billion global market in 2013. The Western Hemisphere is the second largest -- \$61.5 billion -- end market for semiconductors; followed by Korea at \$34.9 billion, Europe at \$34.8 billion, Japan at \$34.8 billion, and Taiwan at \$20 billion.¹¹

Semiconductor Export Opportunities in the Near Term

China represents half of the world market for semiconductors; domestic semiconductor production in China only supplies nine percent of the country's consumption, with imports supplying the balance. China represents the largest and fastest growing export market for U.S. semiconductors, on the strength of the country's extremely large and diverse electronics manufacturing industry. The production of electronics products – especially consumer and automotive electronics – will increase rapidly through 2016.

South Korea has a vibrant consumer electronics manufacturing sector, as well as large automobile manufacturing industry. Singapore is Southeast Asia's window and logistical center to the region. Germany's industrial and automotive sectors are driving demand for semiconductors. Mexico is a top market for semiconductors because of its huge electronics and auto assembly operations serving North America. Taiwan has a large flat panel display industry and is a hub for semiconductor testing and packaging.

Planning for the Long Term

As electronics production shifts to lower cost countries, U.S. companies should think about entering or increasing their sales in Vietnam, India, Brazil, the Philippines, Indonesia, and Turkey.

Sector Case Study: Semiconductor Manufacturing Equipment

The U.S. semiconductor manufacturing equipment (SME) industry is benefitting from the cyclical upturn in the wake of increasing semiconductor sales around the world. U.S. companies are leaders in this industry; only Japanese and Dutch manufacturers are major contenders. The premier trade show for this industry, SEMICON West is an International Buyer Program (IBP) Select Show for the first time in 2015. The world market grew from \$31.8 to \$37.5 billion from 2013 to 2014¹², and is expected to reach \$43.8 (17.1 percent increase) in 2015. After flattening in 2016¹³, the market is expected to enter another cyclical upturn.

Taiwan is the largest market for U.S. SME exports, followed by Korea, China, Japan, Singapore, Germany, the Netherlands, Israel and Malaysia. The average over 2009-2013 is used because in a single year one country's ranking can change dramatically due to a large fab equipment investment or equipping of a new semiconductor fab.

U.S. companies lead in the SME sector, with 44 percent share of the world market.¹⁴ Japan is second, with 32 percent share.¹⁵ Estimates based on sales of IC (integrated circuit) manufacturing equipment identify the Netherlands (less than 20 percent share) as the only other major player; South Korea and Germany have less than 3 percent share each, and China, Taiwan, Singapore, and a few other, mostly European countries have 0.5 percent share or less each.¹⁶

U.S. companies are also leaders in most SME subsectors, except Lithography --where Dutch and Japanese manufacturers are the leading global suppliers-- and cleaning and drying equipment.¹⁷ There are U.S. suppliers in these subsectors as well (such as U.S. lithography equipment company Ultratech). Even in Lithography, U.S. companies are known suppliers of parts and accessories to ASML (Netherlands). Eighty-two percent of U.S. SME exports to the Netherlands are accessories and parts -- far exceeding the 22 percent share for accessories and parts for U.S. exports to the world. This contributes to the Netherlands' place among the top 10 export markets (and second largest European market), even though it has only a few semiconductor fabs.¹⁸

Overview of Global Export Opportunities

In 2014, 88 percent of worldwide sales of SME were in five markets: Taiwan, Korea, China, Japan and the U.S./North America, creating a very concentrated market. Europe and the Middle East (primarily Israel)

represented another six percent, and Other markets (primarily SE Asia) accounting for six percent of the world market.¹⁹ Worldwide sales in general track with U.S. exports, except in the case of Japan -- which is a major competitor, and North America, which consists almost exclusively of the United States market.

The Semiconductor Manufacturing Equipment Export Opportunity in the Near Term

For the first time, SEMICON West, the premier show for SME and semiconductor materials (held in San Francisco, CA) will be a Department of Commerce International Buyer Program (IBP) Select Show. In previous years, both SEMICON Taiwan, and SEMICON Japan were Department of Commerce certified trade shows. There also are SEMICON shows in China, Korea, Europe, and Southeast Asia.

A successful conclusion of the WTO Information Technology Agreement (WTO ITA) expansion negotiations would represent increased opportunities for this industry, as the proposed scope includes some semiconductor manufacturing equipment and accessories that were not clearly included in the scope of the original WTO ITA.

Top Semiconductor Manufacturing Equipment Export Markets to 2016

1. Taiwan
2. South Korea
3. China
4. Japan
5. Singapore
6. Germany
7. Netherlands
8. Ireland
9. Israel
10. Malaysia

Taiwan, Korea, and Japan will continue to be the principal markets through 2016. Planned fab upgrades and new fab equipping will drive this growth. China has substantial plans for equipping fabs for 2015. For Europe and the Middle East, much of the expected growth is due to Intel upgrading fabs in Ireland and Israel. Germany and the Netherlands will continue to be established export markets, as will other European countries. In the Southeast Asia and other market category, Singapore will continue to be the largest market, with sales continuing elsewhere in Southeast Asia as well.

Six Semicondutores' upgrade of its fab in Brazil and the planned equipping of the CNS/Saigon fab in Vietnam will also contribute to the expected jump in "Other Market" sales for 2015. However, both fabs are manufacturing older technology semiconductors. As a result, neither fab will require leading edge equipment and most of the purchases will be used equipment.²⁰ In addition, in June 2014 Six Semicondutores bought the former LFoundry Rousset fab (France) in order to obtain the equipment from that facility to equip its own fab.²¹

Therefore, the best markets will continue to be the established ones with working fabs – though there will be opportunities for some U.S. companies in Brazil and Vietnam.

Planning for the Long Term

India's Department of Electronics and Information Technology ("DeitY") has established a National Policy for Electronics, including an incentive program for ESDM (Electronics Systems Design and Manufacturing).

The flagship projects for the ESDM program are semiconductor fab projects announced by two international consortia. These consortia consist of Indian, U.S. (IBM), European (ST Microsystems), Israeli (Tower Semiconductor), and Malaysian (Silterra) firms. If the plans remain on schedule, equipment purchases should start around 2018, however new fab plans are often stretched out or cancelled.

In addition, these fabs will start out with older generation technology with plans to upgrade later. This means that they probably will start out with used equipment. Recently, a third fab project was announced by U.S. startup Cricket Semiconductor, to manufacturing analog semiconductors in India.²²

Although no one can be sure of the exact date - as current technology equipment has been tweaked in the past to produce finer and finer linewidths, and new packaging technologies have stacked IC components closer together- industry experts predict there needs to be a technology change in SME and semiconductor technology around 2018 to continue the progression in semiconductor technology.²³

Therefore, it is difficult to make projections past 2018. If the usual three-year cycle continues without the need of new technologies, the two likely growth years of 2017 and 2018 will be followed by a cyclical downturn around 2019. Nevertheless, the overall trend will continue upward. The top export markets rankings in general are not expected to change, with the possible exception of Japan and China trading places, and if plans are fulfilled, India will spike into a much higher spot in the rankings with the equipping of its fabs around 2018.

Country Case Studies

The following pages include country case studies that summarize export opportunities in selected markets. The overviews outline ITA's analysis of the U.S. export potential in each market. The top four markets for both sectors are represented.

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China

China represents the largest and fastest growing country market for U.S. semiconductors. China is the third largest country market for U.S. semiconductor manufacturing equipment and the fastest growing market for such equipment.

Semiconductors

1

Semiconductor Manufacturing Equipment

3

China is the top market for semiconductors. However, U.S. companies face IPR problems, and issues stemming from China's program to develop its indigenous integrated circuit industry. China ranks third as a market for U.S. semiconductor manufacturing equipment.

Semiconductors

China ranks number one in our study based on semiconductor demand in its electronics manufacturing industry. China is the largest and fastest growing semiconductor market in the world, representing 50 percent (\$168 billion) of the \$336 billion global market in 2014. China's market is forecast to grow ten percent per year from \$168 billion in 2014 to \$203 billion in 2016. In 2014, U.S. companies had 51 percent of worldwide semiconductor sales, while Chinese companies only had a 4 percent share.²⁴

Growth is being propelled by an increase in domestic consumption of consumer electronic products, as well as consumer electronics assembled for export; growth in the manufacturing of automobiles which are increasingly reliant on electronics; and expanding demand for medical and healthcare electronics. Semiconductor demand growth is forecast to remain in the double digits for years to come. U.S. companies have been successful in selling into the Chinese market, but dark clouds loom over the horizon as the Chinese government has started an initiative to pour up to \$150 billion into developing its domestic semiconductor industry over the next ten years.

China is the largest assembler and manufacturer of ICT and other electronics products in the world and is one of the top semiconductor packaging/final assembly economies in the world.²⁵ Most electronics equipment

assembly in China (which is concentrated in the Pearl River Delta) is done by contract electronics manufacturing companies -- such as Hon Hai Precision Industries (known as Foxconn) which assembles Apple iPhones and other electronics equipment. China's appetite for semiconductors (which are assembled into electronics equipment both for export and for domestic use) is so great that domestic production only counts for nine percent of consumption -- leaving 91 percent of China's demand to be satisfied from imports. However, in quite a few instances the semiconductor buying decision is made outside of China.²⁶

To counter the dearth of domestic semiconductor design and production the Chinese government has unveiled an ambitious plan -- China's National Integrated Circuits Industry Development Plan -- with the goal of establishing a world-leading semiconductor industry in all areas of the integrated circuit supply chain by 2030.

Semiconductor Manufacturing Equipment

China ranks third as a market for U.S. semiconductor manufacturing equipment. The country's domestic semiconductor industry is still relatively small but growing. Total global sales of semiconductor manufacturing equipment in China reached \$4.4 Billion in 2014 (12 percent of the \$37.5 Billion world market), up 57 percent over 2013. China is increasing semiconductor production/fabrication facility (fab) capacity and buying more equipment, but the majority of new facilities are for Light-Emitting Diodes (LEDs), not integrated circuits (ICs).²⁷ With respect to integrated circuits Korean company Samsung is in the process of equipping a fab in China.^{28,29}

In addition to wafer processing equipment for ICs and LEDs, China also buys a significant amount of machinery for semiconductor packaging/final assembly and testing. China represents 27 percent of the world's floor space for semiconductor packaging and testing in the world.³⁰ China produces a nominal amount of semiconductor manufacturing equipment, less than 0.5 percent share of the world market.³¹

Challenges and Barriers to U.S. Semiconductor and Semiconductor Manufacturing Equipment Exports

U.S. semiconductor and semiconductor manufacturing equipment companies enjoy duty-free access to the Chinese market because the WTO Information Technology Agreement (WTO ITA) covers most of their products. However, some types of new-technology semiconductors -- Multi-Component semiconductors (MCOs) -- and some types of semiconductor manufacturing equipment not specifically named in the 1996 agreement may be subject to a duty.

Semiconductors –IC Industry Development Fund

Chinese leadership views their country's reliance on foreign ICs as a major strategic threat. On June 24, 2014 the Ministry of Industry and Information Technology (MIIT), the Ministry of Finance (MOF), the National Development and Reform Commission (NDRC), and the Ministry of Science and Technology (MOST) published the "Guidelines to Promote National IC Industry Development", a central government document outlining measures to support an aggressive growth strategy for China's semiconductor industry. MIIT is the lead ministry responsible for drafting and implementing this policy.

Semiconductors – Counterfeit ICs

According to the Semiconductor Industry Association (SIA) counterfeit semiconductors cost the U.S. semiconductor industry an estimated \$7.5 billion per year, which translates into nearly 11,000 lost American jobs.³² Counterfeit semiconductors pose serious risks to global supply chains, public health and safety, and civilian and military infrastructure. They are a growing problem for the United States and many other countries, despite gradual improvements in IPR enforcement around the world. Often harvested from electronic waste (e-waste), most counterfeit semiconductors are components re-marked or repackaged to indicate they are newer than the originals or they perform to a higher standard.

Semiconductor companies and their authorized distributors, resellers, and aftermarket distributors/manufacturers have extensive, proven controls to ensure products are properly manufactured, tested, handled, and stored to prevent failures. Counterfeiters have few if any such controls. The result is that, unlike legitimate semiconductors from authorized sources, counterfeits and other semiconductors available from non-authorized sources often have low quality and poor reliability.

Due to the dangers posed by counterfeits, the Semiconductor Industry Association Anti-Counterfeiting Task Force (ACTF) works to curtail the supply of and demand for these illegal products and educates customers on how to avoid purchasing counterfeits. The ACTF works closely with government agencies worldwide, including customs and law enforcement, to identify and stop parties involved in manufacturing or trafficking in counterfeit goods. In addition, the ACTF has been instrumental in driving anti-counterfeiting legislation, regulations, and policies. The ACTF conveys counterfeit component avoidance strategies via conferences, webinars, and white papers.

Counterfeit semiconductors have proliferated due to poor purchasing and supply chain practices. Counterfeits reported to SIA member companies and reported through the Government-Industry Data Exchange Program (GIDEP) consistently involve purchases from open market sources that are not authorized by the Original Component Manufacturers (OCMs) to manufacture or sell semiconductor products. The open market includes independent distributors, brokers, and on-line component exchanges that obtain products from a wide range of suppliers. Unfortunately, some suppliers either intentionally or unknowingly introduce counterfeits into the open market supply chain.

The only way to ensure that semiconductor components are authentic, and have optimal quality and reliability levels, is to buy them exclusively through authorized sources. The upfront costs of products purchased through authorized sources are sometimes higher than those offered by open market sources. However, products purchased through authorized sources are usually more cost effective in the long term, since they have superior quality and reliability levels, and carry full factory warranties.

Semiconductor Manufacturing Equipment – IP Issues

The U.S. semiconductor manufacturing equipment industry reports some concern over protection of IPR in China, although these concerns are not of the same magnitude as the problem of counterfeit semiconductor components. Protection of semiconductor manufacturing equipment IP in China is a lesser concern than in some other economies because of China's lower technical level and lack of leadership in semiconductor manufacturing equipment, but is still a disincentive to selling in the market.³³

Opportunities for U.S. Companies

Most semiconductors and semiconductor manufacturing equipment have duty-free access to the Chinese market under the existing WTO Information Technology Agreement. If the WTO Information Technology Agreement expansion is successfully concluded, certain types of semiconductors and semiconductor manufacturing equipment, accessories, and parts whose coverage is in question under the original Agreement will be eligible for duty free trade. This would ensure that U.S. exporters compete on level terms with non-U.S. suppliers, creating potential opportunities for U.S. companies.

Semiconductors

China accounts for over 50 percent of the world's electronics production, which is the main driver of

semiconductor demand. However, not all of the buying decisions for semiconductors are made in China. Such decisions are often made by the foreign companies that contract out electronic goods production to China. The supply chain is global and semiconductors in different stages of completion are transshipped and re-exported from numerous markets. ITA thus encourages U.S. companies to target large Chinese consumer electronics companies manufacturing in China. Lenovo and Huawei, for example, are among the top ten buyers of semiconductors globally, and other Chinese companies including ZTE, Datang Telecomm, Xiaomi, and Haier are also major purchasers.

Semiconductor Manufacturing Equipment

Overall sales of equipment in China are forecasted to grow by 57 percent in 2015 to \$5.1 billion due to fab equipping. Sales are expected to slow later in 2015 as the fab building frenzy declines, and fall to \$4.6 billion in 2016 (down 10 percent year-on-year) with China dropping to become fourth largest market behind Japan.³⁴ China's market is volatile and not as big as those of Taiwan or Korea are. The National IC Industry Development plan creates opportunities but the projects funded may spur artificial demand for semiconductor manufacturing equipment. In addition, there are some IPR issues. However, overall, the U.S. semiconductor manufacturing equipment industry enjoys good access to the Chinese market.

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Germany

Germany is a manufacturing powerhouse when it comes to automobile electronics, industrial electronics, and medical electronics -- all important end markets for semiconductors. The U.S. is the top source of semiconductor manufacturing equipment (SME) imports into Germany. As a member of the European Union (EU), Germany is a participant in the WTO Information Technology Agreement, so most types of semiconductors and SME enter the country duty-free. There are also no significant non-tariff barriers in Germany for semiconductors or semiconductor manufacturing equipment.

Semiconductors

3

Semiconductor Manufacturing Equipment

6

Germany is the fourth largest manufacturer of electronics products in the world. German industrial electronics production accounts for 50 percent³⁵ of total European output. Together with its high production volume, Germany's open trade regime, lack of non-tariff barriers, and straightforward business culture make it a priority market for U.S. semiconductor companies.

Germany is the sixth largest export market for U.S. semiconductor manufacturing equipment (SME). While Germany is the leading European market for SME, the European semiconductor industry overall has declined in importance in comparison to Asian economies such as Taiwan, Korea, and Japan, and therefore the market for the equipment for manufacturing semiconductors has also declined.

Semiconductors

Germany imported \$18.1 billion of semiconductors in 2013³⁶, with imports from the United States reaching \$2.3 billion.³⁷ This figure is deceiving, however, since many U.S. companies design and manufacture their semiconductors in the U.S., but export them to third countries for final assembly/packaging³⁸ and testing, and then ship to Germany from these third countries. Total sales of U.S. semiconductors in Germany are therefore larger than U.S. exports alone.

As Europe's largest electronics producing nation, Germany is a significant but mature market for U.S. semiconductors. Automotive electronics production (valued at \$19.5 billion in 2013)³⁹ is the largest sector of the German electronics industry with a 39.6 percent share; industrial electronics is the second largest sector with 25.1 percent share of German production and also representing 50

percent of Europe's total industrial electronics market.⁴⁰ Germany's electronics production is expected to grow from \$34.9 billion in 2014 to \$36.9 billion in 2016,⁴¹ an annual average growth rate of 3 percent.

Semiconductor Manufacturing Equipment

Germany is the largest European market for semiconductor manufacturing equipment (SME). Average annual U.S. exports (from 2009-2013) were \$587 million, and the United States is the top supplier of SME into Germany with over 30 percent market share. Ireland surpassed Germany as a U.S. SME export market in 2014, but this was due to Intel's upgrade of its semiconductor fabs (semiconductor fabrication/manufacturing facilities) in that country, rather than long term growth.⁴² Depending on the year, the Netherlands sometimes surpasses Germany as a U.S. export market, however on the average, Germany is a larger market than the Netherlands.⁴³ In addition, demand in the Netherlands is primarily for parts and auxiliary accessories.

Challenges and Barriers to U.S. Semiconductor and Semiconductor Manufacturing Equipment Exports

Overall, there are no barriers to accessing the semiconductor and semiconductor manufacturing equipment markets in Germany. Most U.S. exports of semiconductors and semiconductor manufacturing equipment enter the country duty-free because Germany, as an EU member state, participates in the WTO Information Technology Agreement.

Semiconductors

The European semiconductor industry is greatly diminished (currently Europe's share of the global semiconductor market is less than 10 percent), as quite a bit of production has moved to Asia, but the European Commission has taken action to counter this trend with the 2013 launch of its "10/100/20" strategy to increase Europe's share of the global semiconductor market to 20 percent by 2020.⁴⁴

Former EU Commission Vice-President Neelie Kroes, charged with enhancing the bloc's competitiveness in IT and telecommunications, outlined a plan to use EUR 10 billion in public and private funding to kick-start investment of EUR 100 billion by industry. The plan will use a multi-pronged approach: boosting cross-border cooperation; allowing easier access to capital financing through loans; simplifying European state-aid rules; aligning EU, national, and financial resources to enable larger-scale projects; and creating and maintaining a highly skilled workforce.⁴⁵

Foreign companies are not excluded from the 10/100/20 program, which is aimed at all companies interested in investing in manufacturing in Europe. According to market research firm IC Insights, 71 percent of all new integrated circuit capacity needs between 2014 and 2020 would have to be located in Europe in order to meet the 20 percent goal. If this program is successful, a revived EU semiconductor industry could pose a greater competitive challenge to U.S. companies than it does at present.

Semiconductor Manufacturing Equipment

Although some German companies produce SME, German production represents less than 5 percent share of worldwide integrated circuit manufacturing equipment sales.⁴⁶ U.S. companies, the global leaders in SME, face competition in Germany from Dutch and Japanese firms, which also have good

sales networks in Germany. U.S. suppliers face no significant trade barriers to entering the German SME market.⁴⁷

Opportunities for U.S. Companies

German manufacturers of automotive and industrial electronic products are large buyers of semiconductors that offer growth potential for U.S. companies. Germany is the top European market for semiconductor manufacturing equipment and U.S. suppliers are strong competitors there.

Semiconductors

With electronics and infotainment becoming more prevalent in automobiles, Germany's vast and innovative automobile manufacturing industry presents attractive export opportunities for U.S. semiconductor companies. German prowess in industrial automation, robotics, and electronic process controls for every type of manufacturing and processing industry represents good opportunities for U.S. semiconductor companies selling into the industrial market. Germany's thriving and technically advanced electro-medical manufacturing industry also provides export opportunities for U.S. semiconductor companies selling into this end market.

Semiconductor Manufacturing Equipment

The European and Middle East market for SME, which includes Germany, is expected to grow from \$2.4 to \$4.3 billion, an average annual growth rate of 36 percent, from 2014 to 2016. However, some of this upsurge is due to Intel's fab upgrades in Ireland and Israel⁴⁸, and the growth rate for Germany will probably be closer to that of the world average annual growth rate of 8 percent.^{49,50} Germany and other European countries will continue to be good markets for SME for the foreseeable future.

Japan

Japan has the third largest electronics manufacturing industry in the world and is home to two of the top ten semiconductor buying companies, Sony and Toshiba. Japan is the fourth largest export market for semiconductor manufacturing equipment (SME). Japan is a participant in the WTO Information Technology Agreement (WTO ITA), so most types of semiconductors and semiconductor manufacturing equipment enter the country duty-free. There are also no non-tariff barriers in Japan for semiconductors or semiconductor manufacturing equipment. This makes it an attractive market.

Semiconductors

2

Semiconductor Manufacturing Equipment

4

Semiconductors

Japan imported \$24.5 billion of semiconductors in 2013⁵¹ and imports from the U.S. totaled \$2.8 billion⁵², indicating U.S. share of Japanese imports of a little over 11 percent. However, this figure is deceiving since many U.S. companies manufacture their semiconductors in the United States, but then contract the final assembly/packaging⁵³ and test steps in third countries, from which finished semiconductors are exported to Japan. Japan is a large, mature market for U.S. semiconductor companies, ranking second overall worldwide. Imports into Japan are very competitive – with China and Taiwan accounting for fifty percent market share.

Japan's electronics products industry, which is the third largest in the world, is the largest demand factor driving sales of semiconductors to Japan. Japanese electronics production is expected to grow from \$93.0 billion to \$97.2 billion from 2014 to 2016,⁵⁴ an average annual growth rate of 4 percent. According to the Japan Electronics and Information Technology Industries Association (JEITA), in 2013 Japanese electronics and IT companies manufactured 35 percent of their products in Japan.

For high tech electronics the percentage is significantly higher – 88 percent of display devices were manufactured in Japan, 64 percent of electric measuring instrumentation, 75 percent of server/storage equipment, and 63 percent of medical equipment. The largest Japanese consumer electronics companies missed out on the mobile communications revolution and have been operating at substantial losses producing commoditized consumer electronic products, and companies such

as Sony, Panasonic, Sharp, Toshiba, and Hitachi are in the process of restructuring. Japan's once-formidable semiconductor industry is greatly diminished today, with some firms going bankrupt, plants closing, assets being divested and companies being sold. For example, in 2013 Micron (USA) purchased Elpida Memory (Japan) to create the fifth largest semiconductor company in the world. A lot of chip manufacturing capacity and sales activity has moved outside of Japan to rivals such as Korea's Samsung Electronics and Taiwan's TSMC.

Semiconductor Manufacturing Equipment

Japan is the fourth largest U.S. export market for semiconductor manufacturing equipment (SME). U.S. SME sales to Japan reached \$4.2 billion in 2014⁵⁵, and are projected to reach \$4.7 billion in 2016. Average annual growth rate is projected at 6.2 percent, slightly lower than the world average growth rate of 8 percent.⁵⁶

Recently, Digitimes reported that Japan's production of semiconductors grew 8.7 percent from 2013 to 2014,⁵⁷ which shows the industry may now be recovering. This bodes well for future SME sales.

Challenges and Barriers to U.S. Semiconductor and Semiconductor Manufacturing Equipment Exports

Semiconductors

Overall, U.S. semiconductor manufacturers enjoy barrier-free access to Japan's semiconductor market. Japanese semiconductor device producers do not present a very strong challenge, but Korean and Chinese chipmakers provide competition in some types of semiconductors.

Semiconductor Manufacturing Equipment

Overall, U.S. semiconductor manufacturers enjoy barrier-free access to Japan's semiconductor manufacturing equipment market as well, but Japan can be a challenging market for U.S. companies due to the in-market competitors.⁵⁸ Japan's share of the global semiconductor manufacturing equipment market – 32 percent – is ranked second after the United States' 44 percent share.⁵⁹

Opportunities for U.S. Companies

The electronics products manufacturing sector is Japan's largest end market for semiconductors. With electronics and infotainment becoming more prevalent in automobiles, Japan's very large automobile manufacturing industry presents good opportunities for U.S. semiconductor companies.

Semiconductors

The Japan Electronics and Information Technology Industries Association (JEITA) forecasts a second straight year of growth in Japanese electronics manufacturing in 2015, rising 2 percent to reach \$101.7 billion in sales. This means growth

opportunities for U.S. semiconductor companies that supply chips for: display devices in smartphones, which are getting larger and have increasing screen resolution; computer server/data storage equipment (to equip new data centers); electronic measuring instruments and electro-medical equipment; the Internet of Things (IoT); and automobile electronics.

Most semiconductors are imported into Japan tariff-free under the WTO Information Technology Agreement, presenting an opportunity for leading edge U.S. semiconductor companies to access the market.

Semiconductor Manufacturing Equipment

Most SME also enters Japan tariff-free under the Information Technology Agreement. Like most WTO ITA participant economies, Japan has not attempted to protect certain types of SME that are not explicitly specified under the 1996 Information Technology Agreement by creating exceptions in their tariff code. Although Japan's market for SME is not expected to grow at a strong rate from 2015-2016, Japan remains an important, but also competitive, market for U.S. suppliers.

Korea

Korea is the fourth-largest export market for semiconductors, and the second-largest export market for semiconductor manufacturing equipment (SME). Korea is a participant in the WTO Information Technology Agreement, so most types of semiconductors and semiconductor manufacturing equipment enter the country duty-free, and any remaining types have duty-free access under the U.S.-Korea Free Trade Agreement. As a major producer and importer of ICT goods, Korea is a key participant in the WTO Information Technology Agreement expansion negotiations. For semiconductor manufacturing equipment, there are IPR concerns with Korea.

Semiconductors

4

Semiconductor
Manufacturing
Equipment

2

Korea is a large market for U.S. exports of both semiconductors and semiconductor manufacturing equipment (SME). Due to Korea's position as a leading semiconductor producer, it is the second largest market for SME – second as a U.S. export market, and as a world market.

The Korean market is very receptive to both U.S. semiconductors and SME. Korea ranks lower as a market for semiconductors because the country is less important as a location for ICT/electronics equipment assembly. However, semiconductor buying decisions by Samsung, LG and other major electronics equipment manufacturers may be made in Korea, even though the actual product manufacturing and assembly will more likely take place in China. Despite its high ranking, Korea presents some IPR concerns for U.S. SME suppliers.

Semiconductors

Korea is the fourth largest importer of semiconductors in the world and is the world's second largest producer of semiconductors behind the United States. Korea's semiconductor industry is innovative and is currently the United States' largest competitor, with a global market share of 16 percent in 2013.⁶⁰ U.S. companies face stiff competition from Samsung and SK Hynix, the second and fifth largest semiconductor companies in the world. In 2013, semiconductors regained Korea's number one export spot with a record high of \$60 billion.⁶¹ Korea's electronic products industry, which is the largest demand factor for semiconductors, is expected to grow from \$24.7 billion to \$26.2 billion from 2014 to 2016,⁶² an average annual growth rate of 3 percent. Growth will be driven by production of consumer electronics, mobile communications,

displays, the next generation of LCD TVs, Internet-enabled sensors, the Internet of Things, and automotive electronics.

Semiconductor Manufacturing Equipment

U.S. SME companies are well established in the Korean market, and as the world's second largest market, Korea is vital for the U.S. equipment industry.⁶³ Due to continued semiconductor fabrication/manufacturing facility (fab) construction and fab equipment upgrading by Korean semiconductor manufacturers, Korea grew from the third-largest market for SME to second place in 2010, and has remained there ever since. Korea represents 18 percent of the world market for SME. The Korean market is expected to grow from \$6.74 to \$9.11 billion from 2014 to 2016,⁶⁴ an average annual growth rate of 18 percent. Unlike semiconductors, there are no major Korean producers of SME and Korean SME companies have less than 5 percent of the world market.⁶⁵ U.S. equipment suppliers face some IPR issues and Korean semiconductor companies face pressure by the Government of Korea to buy Korean equipment.

The GOK has a long-standing policy goal of increasing Korean companies' share of the Korean and world SME markets. The current goal is to increase Korean manufacturer's share of the world SME market by five percent from 2009 to 2015, and another five percent by 2020, and increase Korean share of the Korean market from 20 percent to 35 percent over the same period. The GOK also has launched the "Semiconductor Equipment Commercialization Project" which encourages Samsung and SK Hynix, the two largest Korean semiconductor companies, to develop major equipment both in subsidiary

companies and in other Korean SME companies for them to purchase.

According to Invest Korea, “recently Korea’s device companies have been determined to localize equipment production and minimize dependence of foreign equipment in order to secure stable supply.”⁶⁶ The large Korean semiconductor companies are trying their best to buy at least some Korean SME, and they do want to have more control over supply. However, Korean attempts to increase their SME market share have not been very successful so far. Korean companies gained less than 1 percent of the worldwide market from 2009 to 2012, and their share of their own national market fell 4 points over the same period. Most of this came from a 10 percent drop in 2010⁶⁷, which was at least partially due the aftereffects of the world financial crisis on the world semiconductor industry.

Challenges and Barriers to U.S. Semiconductor and Semiconductor Manufacturing Equipment Exports

Overall U.S. companies enjoy barrier-free access to the Korea semiconductor and semiconductor manufacturing equipment markets. There is, however, one major concern for semiconductor manufacturing equipment suppliers: protection of intellectual property rights. A lesser challenge is the competition presented to U.S. semiconductor makers by Korea’s semiconductor industry.

Semiconductors

The Korean semiconductor industry is perhaps the most cost-competitive in the world, posing challenges to U.S. semiconductor companies. The GOK, through the South Korean Ministry of Trade, Industry and Energy (MOCIE), has introduced a series of policy initiatives to support the growth of the industry. Policies include measures to expand cooperation between small and medium-sized enterprises and large conglomerates by carrying out detailed projects to develop technologies, nurture human resources, and foster the development of commercialization technologies for system semiconductors for mobile phones, digital appliances (IoT-connected), and electronic systems for automobiles.⁶⁸ The GOK has fostered a strong program to attract foreign direct investment by offering tax breaks for R&D of semiconductors and ICT products. Some U.S. firms have taken advantage of these incentives. For example, Cisco (USA) has

established a global joint R&D center in Korea, and is using it as an R&D headquarters for the development of “smart-cities” technology and products.⁶⁹

Semiconductor Manufacturing Equipment

U.S. companies may confront IPR issues in Korea, some of which appear to be influenced by Korean policies to promote local production of SME. In recent industry surveys, Korea was identified by the semiconductor manufacturing equipment and materials industries as the country of most concern with respect to IPR.⁷⁰

Furthermore, industry has expressed their frustration with certain intellectual property enforcement mechanisms in Korea. SME companies in general are reluctant to file complaints because they report positive outcomes only half the time, and many firms reported that challenging IP violations in court caused business losses and/or forced licensing to keep business.⁷¹

In spite of these issues with IPR protection, Korea is a vital market, and U.S. companies are able to do business there without major problems most of the time.

Opportunities for U.S. Companies

U.S. companies enjoy good access to Korean markets for semiconductors and semiconductor manufacturing equipment. Korea is expected to continue as the second largest semiconductor manufacturing equipment market, and rank among the top five for semiconductors. Semiconductors and semiconductor manufacturing equipment have duty-free access to the Korean market through the WTO Information Technology Agreement and the U.S. – Korea Free Trade Agreement.

Semiconductors

In 2013, Korea imported \$36.5 billion of semiconductors.⁷² Couple that with Korean electronics production of \$24.7 billion in 2014 and you come up with a very attractive market. Korea is a world leader in developing innovative consumer electronics products, including mobile communications, displays (including next-generation Ultra High Definition monitors and televisions), automotive electronics, appliances that digitally talk to one another in a house-hold network (Internet of Things), and “smarter” cars, buildings, and entire

smart cities—all of which require more advanced semiconductors as inputs. Most U.S. semiconductors are imported into Korea tariff-free under the WTO Information Technology Agreement, and the rest are duty free under the U.S.-Korea Free Trade Agreement, presenting an excellent opportunity for leading edge U.S. semiconductor companies to access the market.

Semiconductor Manufacturing Equipment

U.S. exports of SME to Korea in 2014 were valued at \$3.0 billion, a 41 percent increase over 2013. Korea is the second-largest U.S. and global market for SME. The Korean market is forecast to experience significant growth from 2014 to 2016: 19 percent from 2014 to 2015 to over \$8 billion dollars, and another 14 percent from 2015 to 2016, when the market is expected to be worth over \$9 billion. More than 80 percent of SME sold in Korea is imported, and the U.S. is the top producer.

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Taiwan

Taiwan is the top market for semiconductor manufacturing equipment (SME), and the seventh largest U.S. export market for semiconductors. Taiwanese companies are major manufacturers of electronics equipment, with design and buying decisions for semiconductors taking place in Taiwan. Final product assembly most often takes place in China, however, and semiconductor export sales are attributed to that market. Taiwan, a participant in the WTO Information Technology Agreement, presents no significant tariff or non-tariff barriers to U.S. exports in these sectors.

Semiconductors

7

Semiconductor Manufacturing Equipment

1

Semiconductors

Taiwan imported \$34.2 billion of semiconductors in 2013⁷³, with imports from the United States reaching \$2.6 billion.⁷⁴ This figure does not tell the whole story of U.S. semiconductor sales in Taiwan, however, since many U.S. companies design and manufacture their chips in the United States but export them to third countries for final assembly/packaging⁷⁵ and test, and then ship to Taiwan from these third countries. Total sales of U.S. semiconductors in Taiwan are therefore larger than U.S. imports alone.

Major Taiwanese ICT product companies that purchase semiconductors include Acer and ASUSTek (computers and computer parts), and HTC (smart phones).⁷⁶ Assembly of Taiwanese electronics products often takes place in China, but semiconductor buying decisions are made in Taiwan. The largest contract electronics product assembly company in the world, Hon Hai/Foxconn, is a Taiwanese company. Foxconn has manufacturing facilities around the world, but notably in China, where it employs over a million workers.

Taiwan's semiconductor production industry had sales of approximately \$63.4 billion (more than 20 percent of the global total) in 2013 of which \$25.5 billion was from Taiwan's world-leading semiconductor foundry subsector. Major Taiwanese semiconductor companies include Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Company (UMC), both of which serve as foundries (contract semiconductor manufacturing companies) for fabless IC design companies in the United States and elsewhere.⁷⁷ With the cost of building a new semiconductor fab (manufacturing facility) in the billions of dollars, many semiconductor companies worldwide contract their manufacturing to

Taiwan – the largest foundry semiconductor manufacturing economy in the world.

Most Taiwan semiconductor production takes place in science parks, which offer favorable conditions for high tech manufacturing of all sorts. Leading science parks include Taiwan Hsinchu Science Park (HSP), Southern Taiwan Science Park (STSP), and Central Taiwan Science Park (CTSP), with total sales of \$46.5 billion in semiconductor related business for 2014.⁷⁸

Semiconductor Manufacturing Equipment

Taiwan has consistently been the top global market for semiconductor manufacturing equipment in recent years, representing over a quarter of the total worldwide market. The Taiwan market was valued at \$9.4 billion in 2014.⁷⁹ Taiwanese foundries TSMC and its rival UMC are both global leaders in semiconductor manufacturing and buy state of the art semiconductor manufacturing equipment. TSMC is the world's third ranked semiconductor company in estimated capital spending, with \$5.5 billion forecast for 2014. UMC is ranked ninth with forecast capital expenditure of \$1.2 billion.⁸⁰ There are also a number of smaller semiconductor manufacturers in Taiwan, primarily in the memory segment, who also purchase semiconductor processing equipment.

Suppliers of U.S. semiconductor packaging and final assembly equipment (as distinct from semiconductor processing equipment) will also find Taiwan an excellent market. Although China has more total factory floor space dedicated to contract semiconductor packaging/final assembly, Taiwan also hosts a considerable amount of packaging/assembly capacity (Taiwan has nearly 20 percent of factory floor space, China over 27 percent). Also, Taiwanese companies own much of the packaging and assembly

capacity in China and are the leaders in this segment. These Taiwanese companies in many cases make the buying decision for the semiconductor packaging, final assembly and test equipment.⁸¹

Challenges and Barriers to U.S. Semiconductor and Semiconductor Manufacturing Equipment Exports

While Taiwan's semiconductor industry is world-class, it is dominated by foundry manufacturing. Many U.S. fabless semiconductor companies directly benefit from contracting production of their integrated circuit designs to Taiwan. There are a few Taiwan producers of semiconductor manufacturing equipment, but Taiwan has only a minimal share in the SME sector.⁸²

Opportunities for U.S. Companies

Taiwan is open to trade in both semiconductors and semiconductor manufacturing equipment, and presents a good market for U.S. companies. Most semiconductors and semiconductor manufacturing equipment is imported into Taiwan tariff-free under the WTO Information Technology Agreement,

providing leading edge U.S. semiconductor and SME companies unfettered access to the market.

Semiconductors

Taiwan's ICT industry production grew strongly in 2013, rising by 20.5 percent.⁸³ Export opportunities for U.S. companies include: semiconductors used in display products including computer touch-screen panels, smartphone screens, and LCD monitors; semiconductors used in data center equipment (computer servers and data storage and switching equipment) to facilitate the growth in cloud computing; and semiconductors (especially sensors and communications ICs) used in the Internet of Things (IoT) – which will be a major demand driver over the next ten years.

Semiconductor Manufacturing Equipment

Worldwide sales of SME to Taiwan are expected to grow at an average annual rate of 17.5 percent to reach \$12.8 billion in 2016. Taiwan is forecast to remain the top market for semiconductor manufacturing equipment.⁸⁴

Appendix 1: Product Coverage

Figure 1: Semiconductors

HTS6	HTS Product Description
852352	Smart Cards
854110	Diodes, other than photosensitive and light emitting diodes
854121	Transistors, other than photosensitive transistors, less than 1 W
854129	Transistors, other than photosensitive transistors, 1 W or greater
854130	Thyristors, diacs and triacs, other than photosensitive devices
854140	Photosensitive devices, including photovoltaic; light-emitting diodes (LED)
854150	Other semiconductor devices
854190	Parts of 854110-854150; parts of 854160 piezoelectric crystals
854231	Integrated Circuits: Processors and controllers
854232	Integrated Circuits: Memories
854233	Integrated Circuits: Amplifiers
854239	Integrated Circuits: Other
854290	Parts of integrated circuits

Figure 2: Semiconductor Manufacturing Equipment

HTS6	HTS Product Description
848610	Machines for the manufacture of semiconductor boules or bare wafers
848620	Machines for the production of semiconductor devices or integrated circuits
858640	Machines for the manufacture of masks and reticles; assembling semiconductor devices or integrated circuits; lifting, handling, loading and unloading of boules, wafers, semiconductor devices, electronic integrated circuits and flat panel displays.
848690	Parts and accessories for 848610, 848620, 848640; and flat panel display manufacturing equipment (848630)
903082	Instruments and apparatus for measuring or checking semiconductor wafers or devices
903141	Optical instruments and appliances for inspecting semiconductor wafers or devices or for inspecting photomasks or reticles used in manufacturing semiconductor devices

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Appendix 2: Full Country Rankings

Top Semiconductor Export Markets:

1. China
2. Japan
3. Germany
4. South Korea
5. Singapore
6. Mexico
7. Taiwan
8. Malaysia
9. Brazil
10. Thailand
11. France
12. UK
13. Vietnam
14. Italy
15. India
16. Netherlands
17. Hungary
18. Czech Republic
19. Switzerland
20. Canada
21. Sweden
22. Poland
23. Philippines
24. Israel
25. Slovakia
26. Indonesia
27. Ireland
28. Turkey
29. Australia
30. Belgium
31. Russia
32. Austria
33. Spain
34. Finland
35. Portugal
36. Denmark
37. Romania
38. Estonia
39. Norway
40. South Africa

Top Semiconductor Manufacturing Equipment Export Markets

1. Taiwan
2. Korea
3. China
4. Japan
5. Singapore
6. Germany
7. Netherlands
8. Ireland
9. Israel
10. Malaysia
11. France
12. Italy
13. United Kingdom
14. Philippines
15. Austria
16. Belgium
17. Thailand
18. Russia
19. Mexico
20. Switzerland
21. Canada
22. India
23. Denmark
24. Vietnam
25. Brazil

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- ⁷⁴ Taiwan Directorate of Customs.
- ⁷⁵ From Wikipedia: http://en.wikipedia.org/wiki/Integrated_circuit_packaging visited 4/30/2015: "In electronics manufacturing, integrated circuit packaging is the final stage of semiconductor device fabrication, in which the tiny block of semiconducting material is encased in a supporting case that prevents physical damage and corrosion. The case, known as a "package", supports the electrical contacts which connect the device to a circuit board. In the integrated circuit industry it is called simply packaging and sometimes semiconductor device assembly, or simply assembly. Sometimes it is called encapsulation or seal. The packaging stage is followed by testing of the integrated circuit."
- ⁷⁶ A Decade of Unprecedented Growth: China's Impact on the Semiconductor Industry 2014 Update Price Waterhouse Coopers
- ⁷⁷ Ibid.
- ⁷⁸ "Taiwan Science Park Revenues Up 6.28% on year in 2014 says MOST", Digitimes 2/13/2015.
- ⁷⁹ "Worldwide Semiconductor Equipment Market Statistics by Category and by Region" SEMI, 3/2015.
- ⁸⁰ "Three Companies to Account for 52% of Semiconductor CapEx in 2014", IC Insights Research Bulletin 3/20/2014.
- ⁸¹ "IC Manufacturing Equipment Market History and Forecast", 10/2014. VLSI Research
- ⁸² Ibid.
- ⁸³ "Taiwan ICT Industry Backgrounder", Taiwan Excellence USA word-press
- ⁸⁴ "SEMI's 2014 Year –End Semiconductor Equipment Forecast Report" SEMI December 2014

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